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MACRO-MINERAL STATUS AT THREE PHENOLOGICAL STAGES OF SOME RANGE SHRUBS OF GADOON HILLS, DISTRICT SWABI, KHYBER PUKHTUNKHWA, PAKISTAN

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Abstract

The purpose of this study was to evaluate the macro-mineral status of some shrubs species at three phenological stages which are commonly grazed by livestock in Gadoon hills, District Swabi, Pakistan. Eight shrubs species viz., *Berberis lycium, Debregeasia salicifolia, Dodonaea viscosa, Gymnosporia royleana, Indigofera heterantha, Justicia adhatoda, Rosa moschata* and *Zizyphus nummularia* were analyzed for Ca, K, Mg, Na, and N contents. Calcium, Magnesium, Sodium and Nitrogen contents differed significantly among the shrubs and among all phenological stages except *Debregeasia* and *Indigofera* in which the Ca concentration was similar. Potassium contents differed significantly among the various investigated shrubs but such difference was not found among the different phenological stages. *Gymnosporia* showed extremely low nitrogen contents than all other shrubs. The reproductive stage of *Indigofera* contained highest amount of nitrogen among all the shrubs. The present study showed that macro-mineral contents were quite high in all the tested shrubs at all the phenological stages, which generally might fulfill the requirement of grazing animals.

Introduction

Minerals besides constituents of body fluids as electrolytes protect and maintain the structural components of the body organs and tissues. Minerals play a vital role in growth, reproduction, health and proper functioning of the animal's body. The rangelands support about 30 million herds of livestock, which play a key role in Pakistan's annual export income (Anon., 2006). Jones & Martin (1994) reported that grazing of livestock is an important component and the most suitable land use of land management system in nonagricultural marginal areas. Livestock usually derive most of their nutrients from the feed they consume; however, significant quantities of minerals may be obtained from water and soil sources (McDowell, 2003). Poor nutrient availability is the main cause of different physiological disorders, pitiable health and diseases in the livestock of this region (Hussain & Durrani, 2008). Sher *et al.,* (2011) concluded that low concentration of micro-minerals available in some forage shrubs could be a cause of poor productivity at secondary level. Adequate quantities of all the necessary nutrients obligatory for a given physiological stage are needed for good health and productivity of livestock (Yusuf *et al.,* 2003). Meager animal growth and reproductive problems can directly be related to mineral deficiencies caused by low mineral concentration in soils and associated forages even under satisfactory forage supply (Tiffany *et al.*, 2000). The survival and physical condition of plants depend on the regular supply of mineral nutrients from the soil (Tastad *et al*., 2010). It has been suggested that the species with higher Ca, Mg and K in their leaves are more useful for livestock because muscle cramps and spasms emerge in animals are due to deficiency of Ca, Mg and other electrolytes (Khan *et al.*, 2004a; Irigoyen *et al.,* 1992). The mineral composition of range plants is influenced by various environmental factors including geographic aspects, climate, soil minerals, grazing stress, seasonal changes, phenological stages, available palatable species and ability of plant to uptake minerals from soil and assimilate in its body (Ganskopp & Bohnert, 2003; Khan *et al*., 2004b, 2005a, 2006). Gadoon hills offer mountainous rangelands that support a considerable number of animals but with poor health and productivity. Keeping in view the importance of minerals, it is therefore imperative to know the mineral composition and their concentration at different phenological stages of plant life in natural rangelands. The present study was conducted to envisage the macro-mineral status of some shrubby forage plants of the mountainous rangeland.

Materials and Methods

Study area: District Swabi occupies the south and south-western part of Peshawar valley, Khyber Pukhtunkhwa, with an elevation varying from 360 to 2250 m. It lies between latitude 34-0' and 34-25' N and longitude 72-9' and 72-40' E. The North and North-eastern boundary is following for the most part the interfluves of Ambela (Buner) and Gadoon mountains. The Indus River borders the South and South east while the West is separated by Mardan and Nowshera districts. Gadoon tract is hilly lying in the North-eastern part of Swabi District. With the total 27441 ha area, 13921 ha and 8021 ha is occupied by forests and agriculture respectively while the remaining 5499 ha are rangelands. It is bounded by District Buner on the North-West and Utman merged area on East and Panjmand-Pabenai-Topi area of the District Swabi. The altitude of the area varies from 410m on the eastern boundary of Mauza Gandaf to 2250m at Shah Kot Sar (Mahaban forest). The climate of the tract is sub-tropical and semi-arid in the lower reaches and temperate in the upper parts. The area lies between monsoon and western disturbances, resulting in increased rainfall and humidity. Hot summers are the characteristics with June and July as the hottest months having mean maximum temperature of 40-42^{o}C. There is a drop in temperature with rising altitude. Winters are cold. The mean monthly winter temperatures are 4 to 10^oC. January is the coldest month. The annual rainfall varies from 60cm to 145cm, increasing towards upward north and rises in height. Most of the rain is received during the monsoon. Snow fall in the winters is characteristic feature at high altitude. The hilly nature of topography of the tract has resulted in enormous increase in its surface area. The area was once famous for poppy cultivation (Said, 1978) (Fig. 1).

Fig. 1. Map of Gadoon Hills showing the research area.

Collection of plant samples: Plant samples of eight shrubs (Table 1) were collected at three phenological stages (vegetative, reproductive and post reproductive) from Gadoon Hills. They were oven dried at 65^oC for 72 h. The dried powdered samples were stored in plastic bags for all further analysis. Calcium contents were measured at 422.7 nm, potassium at 766.5 nm, magnesium at 285.2 nm and sodium at 589.0 nm using computerized atomic adsorption spectrophotometer following standard procedures (Anon., 1982, 1985; Galyean, 1985). Nitrogen was determined by micro Kjeldahl procedures (Anon., 1990). Nitrogen in the digested sample was collected in 4% boric acid solution by distillation. Boric acid was titrated against 0.02 normal standardized H_2SO_4 by a semi automatic titration apparatus.

Statistical analysis: The data was statistically analyzed through ANOVA using Microsoft excel program (Table 3).

Results and Discussion

Calcium: Calcium, an essential part of the plant cell wall, provides support, rigidity and strength. The present study showed that Calcium contents were quite high in all the tested shrubs at all the phenological stages (Table 2), which generally might fulfill the requirement of grazing animals. Calcium contents ranged from 14.35 ppm (post-reproductive stage of *Berberis*) to 254.5 ppm (reproductive stage of *Indigofera*). Significant differences were found among all phenological stages of all the shrubs except *Debregeasia* and *Indigofera* (Fig. 2) (Table 3). In *Berberis* Ca contents were 91.88 ppm (vegetative stage) and 82.06 ppm (reproductive stage), which abruptly decreased to 14.35 ppm in post-reproductive stage. Vegetative and reproductive stages of *Dodonaea* showed no significant differences in Ca concentration but it increased significantly to 99.4 ppm in the post-reproductive stage. The Ca contents increased to

108.7ppm (reproductive stage) from 106.7ppm (vegetative stage) in *Gymnosporia* but decreased to 100.8ppm in the post reproductive stage. *Debregeasia* and *Indigofera* with mean concentration 251.53 ppm and 251.5 ppm respectively had no significant differences among them and between the various phenological stages. The Ca contents in *Justicia* were 202 ppm, 252.7 ppm and 240.3 ppm in the three consecutive phenological stages. Ca contents in *Rosa* were 144.2 ppm (vegetative stage) and 147.6 ppm (reproductive stage) and abruptly increased to 236.9 ppm in the post-reproductive stage. In *Zizyphus* calcium contents were 249.6 ppm (vegetative stage) and 231.5 ppm (post-reproductive stage) but significantly decreased to 92.17 ppm in reproductive stage. Khan *et al*., (2006) also reported slightly higher Ca contents in the forage grasses of arid pastures than the minimum recommended levels in the diets of ruminants, and our findings agree with them. Low concentration of Ca contents was observed in the post-reproductive stage (maturity) of all the species except for *Justicia, Rosa* and *Zizyphus.* Ashraf *et al*., (2005) and Khan *et al*., (2005b) reported significant increased in Ca concentration in mature forage plants, however present study do not agree with these workers.

Table 1. Shrub species selected for macro-mineral analysis showing their palatability at three phenological stages.

	Species	Palatability at		
		Vegetative stage	Rep stage	Post-rep stage
1.	*Berberis lycium* Royle.nbbbbb	Highly palatable	Highly palatable	Highly palatable
2.	*Debregeasia salicifolia* (D. Don) Rendle	Highly palatable	Highly palatable	Highly palatable
3.	*Dodonaea viscosa* (L.) Jacq.	Non palatable	Non palatable	Rarely palatable
4.	*Gymnosporia royleana* Wall ex Lawson	Highly palatable	Highly palatable	Highly palatable
5.	*Indigofera heterantha* L.	Highly palatable	Highly palatable	Highly palatable
6.	*Justicia adhatoda* L.	Non palatable	Non palatable	Rarely palatable
7.	*Rosa moschata* non J. Herrm.	Highly palatable	Highly palatable	Highly palatable
8.	*Zizyphus nummularia* Buem.f. Weight	Highly palatable	Highly palatable	Highly palatable

Table 2. Macro-mineral composition at three phenological stages of some shrubs of Gadoon hills, District Swabi.

	Species	Phenological stage	Ca (ppm)	K (ppm)	Mg (ppm)	Na (ppm)	N%
1.	*Berberis lycium* Royle	Vegetative	91.88	27.07	9.083	1.555	1.895
		Reproductive	82.06	27.1	8.243	1.568	2.070
		Post-reproductive	14.35	27.1	9.077	2.079	1.561
		Mean	**62.763**	**27.090**	**8.801**	**1.734**	**1.842**
2.	*Debregeasia salicifolia* (D. Don) Rendle	Vegetative	252.4	26.91	11.16	2.254	1.173
		Reproductive	251.5	26.97	10.91	1.994	2.141
		Post-reproductive	250.7	26.96	11.29	1.952	0.885
		Mean	**251.533**	**26.947**	**11.120**	**2.067**	**1.399**
3.	*Dodonaea viscosa* (L.) Jacq.	Vegetative	51.5	27.11	10.26	2.837	2.192
		Reproductive	51.08	27.13	10.26	3.146	1.564
		Post-reproductive	99.4	27.16	10.91	2.03	1.348
		Mean	**67.327**	**27.133**	**10.477**	**2.671**	**1.701**
4.	*Gymnosporia royleana* Wall ex Lawson	Vegetative	106.7	27.08	10.58	1.694	0.042
		Reproductive	108.7	27.1	10.56	2.403	0.547
		Post-reproductive	100.8	27.09	9.638	1.644	0.169
		Mean	**105.4**	**27.090**	**10.259**	**1.914**	**0.252**
5.	*Indigofera heterantha* L.	Vegetative	250.1	27.04	11.69	1.969	0.757
		Reproductive	254.5	27.1	11.68	1.779	3.660
		Post-reproductive	249.9	27.15	11.6	1.681	2.154
		Mean	**251.5**	**27.097**	**11.657**	**1.810**	**2.190**
6.	*Justicia adhatoda* L.	Vegetative	202	26.9	12.48	4.463	2.945
		Reproductive	252.7	26.9	13.08	6.444	2.475
		Post-reproductive	240.3	26.89	12.62	5.716	2.933
		Mean	**231.667**	**26.897**	**12.727**	**5.541**	**2.784**
7.	*Rosa moschata* non J. Herrm.	Vegetative	144.2	27.01	10.42	3.713	2.066
		Reproductive	147.6	27.08	10	2.235	1.263
		Post-reproductive	236.9	27.1	9.992	1.798	1.433
		Mean	**176.233**	**27.063**	**10.137**	**2.582**	**1.587**
8.	*Zizyphus nummularia* Buem.f. Weight	Vegetative	249.6	27.15	9.895	2.295	2.356
		Reproductive	92.17	27.15	11.03	7.879	2.485
		Post-reproductive	213.5	27.16	10.74	7.349	3.041
		Mean	**185.09**	**27.153**	**10.555**	**5.841**	**2.627**

Table 3. ANOVA-Macro-minerals of some shrubs at three phenological stages.

Source of variation	SS	df	MS	F	P-value	F crit
			ANOVA -Calcium			
Shrubs	130417.5	7	18631.08	10.90627	0.000101	2.764199
Phenological stages	1766.059	2	883.0295	0.516908	0.607311	3.738892
Error	23916.06	14	1708.29			
Total	156099.7	23				
Source of variation	**SS**	**df**	**MS**	**F**	**P-value**	**F crit**
			ANOVA -Potassium			
Shrubs	0.170263	7	0.024323	49.35145	8.430-09	2.764199
Phenological stages	0.0079	2	0.00395	8.014493	0.004788	3.738892
Error	0.0069	14	0.000493			
Total	0.185063	23				
Source of variation	**SS**	**df**	**MS**	**F**	**P-value**	**F crit**
			ANOVA-Magnesium			
Shrubs	28.15402	7	4.022003	23.32447	1.084-06	2.764199
Phenological stages	0.00576	2	0.00288	0.016702	0.983456	3.738892
Error	2.414119	14	0.172437			
Total	30.5739	23				
Source of variation	**SS**	**df**	**MS**	**F**	**P-value**	**F crit**
			ANOVA -Sodium			
Shrubs	59.63594	7	8.51942	5.536439	0.003248	2.764199
Phenological stages	2.780408	2	1.390204	0.903439	0.427537	3.738892
Error	21.54307	14	1.538791			
Total	83.95942	23				
Source of variation	**SS**	**df**	**MS**	**F**	**P-value**	**F crit**
			ANOVA -Nitrogen			
Shrubs	13.24869	7	1.89267	4.504762	0.008062	2.764199
Phenological stages	0.621814	2	0.310907	0.739993	0.494883	3.738892
Error	5.882083	14	0.420149			
Total	19.75259	23				

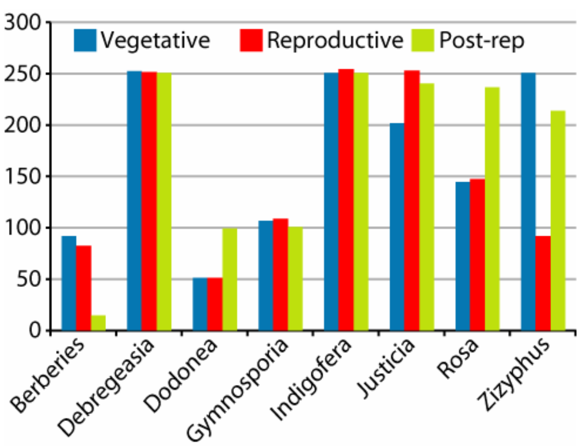

Fig. 2. Calcium contents in forage shrubs of Gadoon hills at three phenological stages.

Potassium: Potassium is an essential nutrient that activates many enzyme systems. Its deficiency adversely affects the plant growth and metabolism (Rahim *et al.,* 2008). Physiological functions of Livestock require at least 0.5 ppm potassium (Anon., 1985). The high potassium contents recorded in the present investigation in all the tested shrubs in all the phenological stages may be sufficient for grazing ruminants. It varied from 26.89 ppm (*Justicia*) to 27.16 ppm in *Dodonaea* & *Zizyphus* (Table 2). Significant differences in potassium concentration were observed among the various shrubs but the differences in phenological stages were insignificant (Fig. 3) (Table 3). However, a slight increase was recorded in *Dodonaea, Indigofera* and *Rosa* on maturity. The present findings regarding the higher concentration of Potassium in the early stages of most of the shrubs are in line with Akhtar *et al.*, (2007) who reported that herbaceous plants and grasses are nutritionally rich at early growing stage. McDowell, (1992) also reported that the concentration of Potassium decreased with advancing maturity. In the present investigation it has been found that *Justicia* had low Potassium contents than the other species studied. This species is usually not preferred by the animals because animals prefer K rich forage plants.

Magnesium: Magnesium contents ranged from 8.243 ppm (reproductive stage of *Berberis*) to 13.08 ppm (reproductive stage of *Justicia*) (Table 2). Significant differences in Mg contents were recorded among the different shrubs and among the different phenological stages (Fig. 4) (Table 3). The vegetative (9.083 ppm) and post-reproductive (9.077 ppm) stages of *Berberis* showed no significant difference which declined with maturity (8.243 ppm). In *Dodonaea* the Mg concentration was similar at vegetative and reproductive (10.26 ppm) stages, which increased (10.91 ppm) at post reproductive stage. Reduced magnesium contents were recorded in the post-reproductive (9.638 ppm) stage of *Gymnosporia* than its vegetative (10.58 ppm) and reproductive (10.56 ppm) stages. *Indigofera* and *Rosa* showed no significant differences among their phenological stages in magnesium levels. The reproductive stage of *Justicia* (13.08 ppm) and *Zizyphus* (11.03 ppm) comparatively had higher Mg contents than other stages. Canali *et al.*, (2005) support our findings who also reported high concentration of Mg in a number of forage plants.

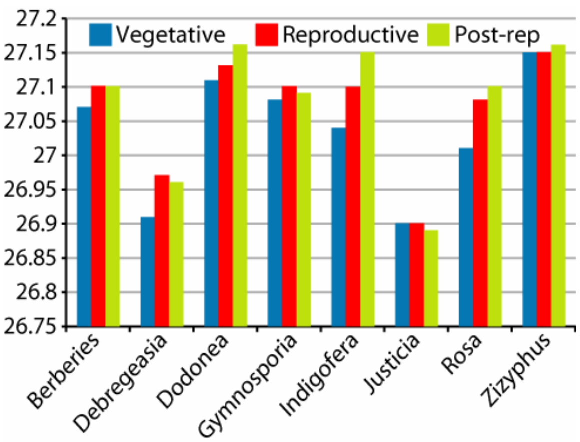

Fig. 3. Potassium contents in forage shrubs of Gadoon hills at three phenological stages.

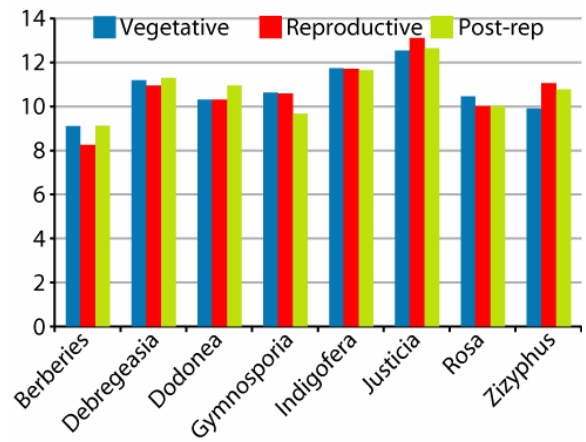

Fig. 4. Magnesium contents in forage shrubs of Gadoon hills at three phenological stages.

Sodium: Significant differences in sodium contents were recorded among the various shrubs and among the different phenological stages of the same plant (Fig. 5) (Table 3). Sodium concentration ranged from 1.555 ppm in *Berberis* (vegetative stage) to 7.879 ppm in *Zizyphus* (reproductive stage). Similar sodium levels were observed in vegetative (1.555 ppm) and reproductive (1.568 ppm) stages of *Berberis* while it increased to 2.079 ppm at the post-reproductive stage. A slight gradual decrease in sodium contents were recorded at various phenological stages of *Debregeasia* and *Indigofera* with maturity. Reproductive (3.146 ppm) stage of *Dodonaea* showed significant differences in Na concentration than vegetative (2.837 ppm) and post-reproductive (2.03 ppm) stages. Vegetative (1.694 ppm) and post-reproductive (1.644 ppm) stages of *Gymnosporia* had less Na contents than reproductive (2.403 ppm) stage. Reproductive stage of *Justicia* (13.08 ppm) and *Zizyphus* (7.879 ppm) showed higher sodium contents than the other two stages. The vegetative and post-reproductive stages of *Justicia* had 4.463 ppm and 5.716 ppm Na contents respectively (Table 2). In *Zizyphus*, the recorded Na contents were 2.295 ppm and 7.349 ppm for vegetative and post-reproductive stages, respectively. A gradual decrease in the Na contents was observed with maturity in *Rosa*. It was 3.713 ppm, 2.235 ppm and 1.798 ppm in the vegetative, reproductive and post-reproductive stages. Khan *et al*., (2006, 2007) and Tiffany *et al.*, (2000) reported deficiency of sodium in various forage plants from different regions therefore; our results are contradictory with them.

Nitrogen: Nitrogen is an important nutritional element for plants. It is a major constituent of all amino acids, which are the building blocks of all proteins, including the enzymes, which control virtually all biological processes (Brady & Weil, 1999). Significant differences were observed in the nitrogen contents among the various investigated shrubs and among the different phenological stages of the same plant (Fig.6) (Table 3). Nitrogen contents varied from 0.042% (*Gymnosporia*) to 3.660% (*Indigofera*). Reproductive stage (2.070%) of *Berberis* had higher nitrogen contents than vegetative (1.895%) and post-reproductive (1.561%) stages. The same trend was also recorded for *Debregeasia* having higher N percentage in reproductive (2.141%) stage than vegetative (1.173%) and post-reproductive (0.885%) stages. The nitrogen contents reduced with advancing maturity in *Dodonaea.* It was 2.192%, 1.564% and 1.348% for vegetative, reproductive and post-reproductive stages respectively (Table 2). *Gymnosporia* showed extremely low nitrogen contents than all studied shrubs. The reproductive (0.547%) stage had higher nitrogen contents than vegetative (0.042%) and post-reproductive (0.169%) stages in *Gymnosporia*. The highest nitrogen contents among all shrubs and phenological stages were observed for *Indigofera* at the reproductive stage. The vegetative and post-reproductive stages had 0.757% and 2.154% nitrogen respectively. The nitrogen levels in *Justicia* were 2.945%, 2.475% and 2.933% in vegetative, reproductive and post-reproductive stages respectively. Higher nitrogen concentration was recorded in the vegetative stage of *Rosa* than the other two stages. In *Zizyphus*, a gradual increase in the nitrogen concentration was observed with maturity. Bignami *et al*., (2005) observed inconsistencies in leaf N content during the growing season. The present findings agree with them because no regular trend was recorded in the investigated shrubs analyzed for nitrogen contents.

It is concluded that required levels of macro-minerals are available in these forage plants the grazing herds in Gadoon hills, hence there is no need to supplement macro-mineral in feed to the ruminants of this area. Nonetheless, further study is needed to search out the cause of poor health and productivity of these animals because mineral availability is not the only reason responsible for the health and productivity of the grazers.

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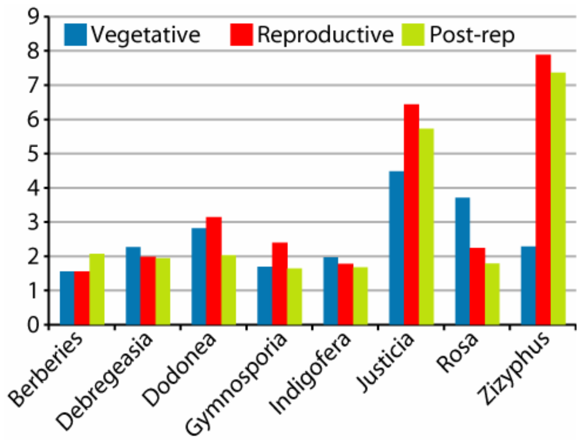

Fig. 5. Sodium contents in forage shrubs of Gadoon hills at three phenological stages.

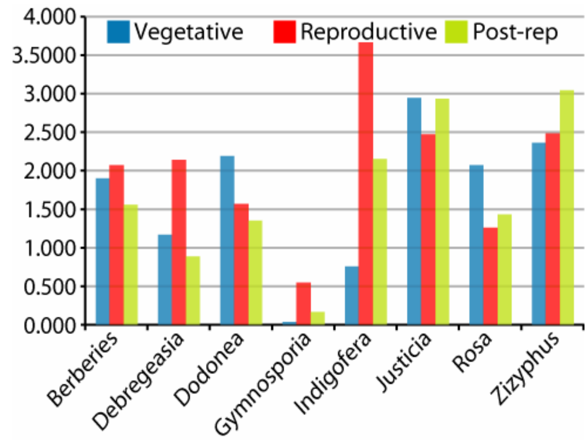

Fig. 6. Nitrogen contents in forage shrubs of Gadoon hills at three phenological stages.

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